ACCOMMODATING INTRAOCULAR LENS

REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my application Ser. No. 07/915,453, filed Jul. 16, 1992, now abandoned, which, in turn, is a continuation-in-part of my application Ser. No. 07/515,636, filed Apr. 27, 1990, now abandoned. Reference is also made to my application Ser. No. 07/744,472 filed Aug. 12, 1991.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to intraocular lenses and more particularly to novel accommodating intraocular lenses for implantation within the capsular bag of a human eye from which the natural lens matrix has been removed by an extraction procedure which leaves intact within the eye the posterior capsule and an anterior capsule remnant of the natural lens. The invention relates also to a novel method of utilizing the intraocular lenses in a human eye to provide the patient with accommodation capability responsive to normal ciliary muscle action.

2. Prior Art

The human eye has an anterior chamber between the cornea and the iris, a posterior chamber behind the iris containing a crystalline lens, a vitreous chamber behind the lens containing vitreous humor, and a retina at the rear of the vitreous chamber. The crystalline lens of a normal human eye has a lens capsule attached about its periphery to the ciliary muscle of the eye by zonules and containing a crystalline lens matrix. This lens capsule has elastic optically clear anterior and posterior membrane-like walls commonly referred by ophtalmologists as anterior and posterior capsules, respectively. Between the iris and ciliary muscle is an annular crevice-like space called the ciliary sulcus.

The human eye possesses natural accommodation capability. Natural accommodation involves relaxation and constriction of the ciliary muscle by the brain to provide the eye with near and distant vision. This ciliary muscle action is automatic and shapes the natural crystalline lens to the appropriate optical configuration for focussing on the retina the light rays entering the eye from the scene being viewed.

The human eye is subject to a variety of disorders which degrade or totally destroy the ability of the eye to function properly. One of the more common of these disorders involves progressive clouding of the natural crystalline lens matrix resulting in the formation of what is referred to as a cataract. It is now common practice to cure a cataract by surgically removing the cataractous human crystalline lens and implanting an artificial intraocular lens in the eye to replace the natural lens. The prior art is replete with a vast assortment of intraocular lenses for this purpose. Examples of such lenses are described in the following U.S. Pat. Nos.: 4,254,509, 4,298,996, 4,409,691, 4,424,597, 4,573,998, 4,664,666, 4,673,406, 4,738,680, 4,753,655, 4,778,463, 4,813,955, 4,840,627, 4,842,601, 4,963,148, 4,994,082, 5,047,051.

As is evident from the above patents, intraocular lenses differ widely in their physical appearance and arrangement. This invention is concerned with intraocular lenses of the kind having a central optical region or optic and haptics which extend outward from the optic and engage the interior of the eye in such a way as to support the optic on the axis of the eye. My above-listed U.S. Pat. No. 5,047,051, which

was filed concurrently with my earlier mentioned application Ser. No. 07/515,636, discloses an intraocular lens having a haptic anchor plate, an optic at the longitudinal center of the plate, and resilient haptic loops staked to the ends of the plate.

Up until the late 1980's, cataracts were surgically removed by either intracapsular extraction involving removal of the entire human lens including both its outer lens capsule and its inner crystalline lens matrix, or by extracapsular extraction involving removal of the anterior capsule of the lens and the inner crystalline lens matrix but leaving intact the posterior capsule of the lens. Such intracapsular and extracapsular procedures are prone to certain post-operative complications which introduce undesirable risks into their utilization. Among the most serious of these complications are opacification of the posterior capsule following extracapsular lens extraction, intraocular lens decentration, cystoid macular edema, retinal detachment, and astigmatism.

Starting in the late 1980's, an improved surgical procedure called capsulorhexis (a form of anterior capsulotomy) was developed to alleviate or avoid the above and other post-operative complications and risks involved in intracapsular and extracapsular cataract extraction. Simply stated, capsulotomy involves forming an opening in the anterior capsule of the natural lens, leaving intact within the eye a capsular bag having an elastic posterior capsule, an anterior capsular remnant about the anterior capsulotomy, and an annular sulcus, referred to herein as a capsular bag sulcus, between the anterior capsule remnant and the outer circumference of the posterior capsule. This capsular bag remains attached about its periphery to the surrounding ciliary muscle of the eye by the zonules of the eye. The cataractous natural lens matrix is extracted from the capsular bag through the anterior capsulotomy by phacoemulsification and aspiration or in some other way after which an intraocular lens is implanted within the bag through the capsulotomy.

The type of anterior capsulotomy known as capsulorhexis involves a continuous tear circular or round capsulotomy, tearing the anterior capsule of the natural lens capsule along a generally circular tear line substantially coaxial with the lens axis and removing the generally circular portion of the anterior capsule surrounded by the tear line. A continuous tear circular capsulorhexis, if performed properly, provides a generally circular capsulotomy through the anterior capsule of the natural lens capsule substantially coaxial with the axis of the eye and surrounded circumferentially by a continuous annular remnant or rim of the anterior capsule having a relatively smooth and continuous inner edge bounding the capsulotomy. During a continuous tear circular capsulorhexis, however, the anterior rim is often accidentally torn or sliced radially or otherwise ruptured, or the inner rim edge is nicked or sliced in a manner which renders the rim prone to tearing radially when the rim is stressed, as it is during fibrosis as discussed below.

Another capsulorhexis procedure, referred to as an envelope capsulorhexis, involves cutting a horizontal incision in the anterior capsule of the natural lens capsule, then cutting two vertical incisions in the anterior capsule intersecting and rising from the horizontal incision, and finally tearing the anterior capsule along a tear line having an upper upwardly arching portion which starts at the upper extremity of the vertical incision and continues in a downward vertical portion parallel to the vertical incision which extends downwardly and then across the second vertical incision. This procedure produces in the anterior capsule a generally archway-shaped envelope capsulotomy centered on the axis